MODIFIED CLAIMS

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original claims 1-37 replaced by the modified claims 1-37 (10 pages)]

1. Multiple-effect distillation method, intended for separating substances in solution from their liquid solvent, in particular for producing fresh water or concentrates, in which:

- counter-current heat exchanges are carried out by a single liquid or gaseous heat-transfer fluid, circulating in closed circuit along surfaces, hot S_c and cold S_f respectively, linked by significant thermal conductance;

- said surfaces S_c and S_f are faces of walls of thin distillation-heat-exchange hollow plates, installed in large numbers, vertical or inclined, in a heat-insulated treatment chamber, comprising narrow inter-plate spaces, of more or less constant width, filled with a non-condensable gas, in particular air at atmospheric pressure;

characterized in that:

- the heat-transfer fluid circulates, in a first upward or downward direction, along the surfaces S_c, passing from a high initial temperature T_1 to a final temperature T_3 below T_1, then in a second direction opposite the first, along the surfaces S_f, passing from an initial temperature T_4, below T_3, to a final temperature T_2, above T_4 and below T_1;

- at the top of the external faces of the walls of the hollow plates, inside which the heat-transfer fluid circulates in said first direction, liquid to be distilled is poured which spreads out and runs down slowly in fine layers along these external faces;

- under the action of the flow of heat-transfer fluid circulating in said first direction, some of the liquid to be distilled poured over said external faces evaporates, whilst this flow cools down, passing from T_1 to T_3, and the vapour produced diffuses in the non-condensable gas present in the inter-plate spaces;

- under the action of the flow of heat-transfer fluid circulating in said second direction, the vapour diffused in the non-condensable gas condenses, whilst this flow heats up again, passing from T_4 to T_2, under the effect of a recovery of a significant part of the latent heat of condensation of the diffused vapour;

- a heat source is arranged between the hottest ends of the surfaces S_c and S_f, in order to increase the temperature of the heat-transfer fluid from T_2 to T_1;

-a cold source is arranged between the least hot ends of these surfaces S_c and S_f, in order to reduce the temperature of the heat-transfer fluid from T_3 to T_4;

- a more or less constant local difference dH in enthalpy flows is established between the surfaces S_c and S_f, by giving appropriate amplitudes to the heat

exchanges carried out between the flow of heat-transfer fluid and said hot and cold sources respectively;

- the optimum temperatures of the heat-transfer fluid T_1, T_2 and T_3, T_4, at the ends of these same surfaces, are determined from the maximum Intrinsic Efficiency Criterion $C_{IE} = Q^2/P.V$ of the installation, Q being the exchanged distillation thermal power, P being the thermal power provided by the heat source, and V the active volume of the installation.

2. Distillation method with vapour diffusion, according to claim 1, in which:

- the heat-transfer fluid is the liquid to be distilled;

- the thin, hollow distillation-heat-exchange plates are hot or cold and they are installed alternating in the heat-insulated treatment chamber, the internal faces of their respective walls constituting said hot S_c and cold surfaces S_f;

- liquid to be distilled is poured over the external faces of the walls of the hot plates only;

characterized in that:

- the heat-transfer liquid circulates, in a first upward or downward direction, inside the hot plates, it enters very hot at temperature T_1 and it exits cooled down to the temperature T_3, having caused a partial evaporation of the liquid to be distilled flowing over the external faces of the walls of these hot plates;

- at the outlet from these hot plates, the heat-transfer liquid at temperature T_3 is cooled down to temperature T_4;

- then, the heat-transfer liquid at temperature T_4 enters inside the cold plates where it circulates in a second direction, opposite the first, causing, on the external faces of the walls of these cold plates, a condensation of the vapour diffused through the layer of non-condensable gas in the inter-plate space and recovering some of the condensation heat from this vapour in order to be heated up again, and finally it exits from the cold plates at temperature T_2;

- during these operations, the flow of heat passes through the walls of the hot and cold hollow plates as well as the immobile layers of non-condensable gas which separate them;

- the distilled liquid runs down along the external faces of the walls of the cold plates whilst the concentrated liquid runs down along the external faces of the walls of the hot plates;

- the optimum temperature T_1 of the heat-transfer liquid, at the inlet to the hot hollow plates, is as little as possible below the boiling temperature of this liquid at atmospheric pressure;

- the optimum temperature T_3 of the heat-transfer liquid, at the outlet from the hot hollow plates, is relatively high and situated in a range which corresponds to a zone surrounding the maximum Intrinsic Efficiency Criterion C_{IE} of the installation;

- the differences in temperature (T_1-T_2) and (T_3-T_4) are small, with (T_1-T_2) being slightly greater than (T_3-T_4).

3. Distillation method with vapour diffusion and heat-transfer liquid, according to claim 2, characterized in that:

- the correspondence between the optimum range of the temperatures T_3 and the maximum C_{IE}, is achieved by means of their respective relationships with a composite variable t.dT, in which t is the transit time of the heat-transfer liquid in the plates and dT the difference in temperature between the liquids circulating in the cold and hot hollow plates;

- the optimum difference in temperature dT is established by an adjustment of the ratio between the heating power of the heat source and the mass flow rate D of circulating heat-transfer liquid;

- the optimum value chosen for dT is relatively high when the unit cost of the thermal energy easily available at the site of implementation of the method is relatively low;

- the useful range of the temperature T3 is the range from 58 to 78°C, when the liquid to be distilled is water;

- the optimum transit time t of the heat-transfer fluid in the heat-exchange plates is established by adjustment of the mass flow rate D of the heat-transfer liquid circulating in a closed loop.

4. Distillation method with vapour diffusion and heat-transfer liquid, according to claim 2 or 3, in which the heat-transfer liquid circulates, by thermosiphon or by pumping, from the top downwards inside the hot hollow plates and from the bottom upwards inside the cold hollow plates, characterized in that:

- a heat exchange for heating is carried out between the flow d of liquid to be distilled entering the installation at temperature T_{L1} and the two flows of distilled and concentrated liquids leaving it, so as to take the temperature of this flow d to a relatively high optimum intermediate value T_{L2};

- mixing is carried out between this entering flow d thus heated and the flow D of heat-transfer liquid exiting from the hot plates at temperature T_3, the ratio d/D being adjusted so that the mixture thus produced is at an optimum temperature T_4 at the inlet to the cold plates.

5. Distillation method with vapour diffusion and heat-transfer liquid, according to claim 2 or 3, characterized in that:

- the heat-transfer liquid circulates by thermosiphon, from the bottom upwards inside the hot hollow plates and from the top downwards inside the cold hollow plates;

- the flow d of liquid to be distilled entering at temperature T_{L1} is added to the flow D of heat-transfer liquid exiting at the temperature T_3 of the hot plates, the ratio d/D being adjusted so that the mixture thus produced is at an optimum temperature T_4 at the inlet to the cold plates;

- a flow d of liquid at temperature T_3 or T_4 is poured over the top of the external faces of the hot plates.

6. Distillation method with vapour diffusion, according to claim 1, in which:

-the heat-transfer fluid is said non-condensable gas, saturated with vapour of the liquid to be distilled;

- liquid to be distilled is poured over the top of the external faces of the walls of all the distillation-heat-exchange hollow plates, these external faces constituting said cold surfaces S_f whilst the internal faces of the walls of these plates constitute said hot surfaces S_c;

characterized in that:

- the flow of heat-transfer gas at temperature T_1 enters inside all the hollow distillation plates, where it circulates in a first upward or downward direction, whilst some of its vapour condenses on the internal faces of the walls of the plates, flows of heat, resulting from a virtually total recovery of the latent heat of condensation, pass through the walls of the plates in order to evaporate some of the liquid flowing over the external faces of these walls and, as a result, this flow of gas cools down and finally exits from the hollow plates at temperature T_3;

- at the outlet from these plates, this flow of heat-transfer gas at temperature T_3 is cooled down to temperature T_4 by heat exchange and the distilled liquid, condensed on this occasion, is recovered;

- then, this flow of heat-transfer gas, at temperature T_4, enters the inter-plate spaces, where it circulates in a second direction, the reverse of the first, carrying away the vapour produced in these spaces and reheating it, and finally it exits from these spaces at temperature T_2;

- the distilled liquid, condensed on the internal faces of the walls of the hollow plates, runs down along these internal faces whilst the concentrated liquid runs down along the external faces of these walls;

- the optimum temperature T_1 of the flow of heat-transfer gas, at the inlet to the hollow plates, is situated within a wide range surrounding the maximum Intrinsic Efficiency Criterion C_{IE} of the installation;

- the temperature T_4 of the flow of heat-transfer gas, at the inlet to the inter-plate spaces, is optimum when, by appropriate cooling, it is made as close as possible to the minimum temperature of the natural cold source available at the site;

- the difference in temperature (T_1-T_2) is small and the difference (T_3-T_4), considerable.

7. Distillation method with vapour diffusion and heat-transfer gas, according to claim 6, characterized in that:

- the correspondence between the optimum range of the temperatures T_1 and the maximum C_{IE} zone is achieved by means of their respective relationships with a composite variable t.dH/V, in which t is the transit time of the heat-transfer gas in the hollow plates and dH a more or less constant local difference in enthalpy flows between the internal and external faces of the walls of the hollow plates;

- the useful range of the temperature T1 is approximately comprised between 74 and 91°C;

- the optimum local difference in enthalpy flows dH, between the internal and external faces of the walls of the hollow plates, is established by adjustment of the ratio between the heating power of the heat source and the circulating mass flow rate D of the heat-transfer gas;

- the optimum value of the difference dH is higher when the C_{IE} and the cost of the thermal energy easily available on site are relatively low;

- the optimum transit time t of the flow of heat-transfer gas in the hollow plates is established by adjustment of the mass flow D of this flow of gas.

8. Distillation method with vapour diffusion and heat-transfer gas, according to claim 6 or 7, characterized in that, according to a first set of arrangements,

- the flow of gas at temperature T_1 is introduced at the top of the hollow distillation plates and it exits at the bottom at temperature T_3;

- at the outlet from the hollow distillation plates, this flow of gas at temperature T_3 is subjected to a first cooling-down heat exchange, ensured by a cold source at temperature T_{L1}, constituted by the entering flow of liquid to be distilled, in order that, given the respective mass and thermal characteristics of this flow of gas and of this flow of liquid, the temperature T_3 of the flow of gas is reduced to an optimum temperature T_4 and the temperature of the liquid taken to T_{L2};

- after this heat exchange, the liquid to be distilled at temperature T_{L2} is reheated by a heat source;

- the flow of gas at temperature T_4 is introduced at the bottom of the inter-plate spaces and it exits at the top at temperature T_2;

- the flow of gas circulates in closed circuit in the hollow plates and in the inter-plate spaces, under the action of at least one means of propulsion;

- at the outlet from the inter-plate spaces, the flow of gas at temperature T_2 is reheated and saturated with vapour, by an appropriate physical contact with the liquid to be distilled reheated by the heat source, so as to take on an optimum or simply effective temperature T_1;

- after its physical contact with the flow of gas at temperature T_2, the liquid to be distilled is poured, at a temperature of approximately T_1, over the top of the external faces of the walls of the hollow plates, and it exits at a temperature of approximately T_4;

- the distilled liquid, condensed during said cooling-down heat exchange, and that condensed on the internal faces of the hollow plates, are collected, then removed and recovered;

- the concentrated liquid is collected at the bottom of the external faces of the walls of these plates, then it is removed and, if appropriate, recovered.

9. Distillation method with vapour diffusion and heat-transfer gas, according to claim 8, characterized in that:

- said hollow distillation plates forming a large number N of plates, a small flow of heat-transfer gas at temperature T_1 is introduced into a small number n of hollow auxiliary reheating plates, in order to participate in a second heat exchange, intended to reheat the liquid to be distilled exiting from a third heat exchange;

- the flow of liquid to be distilled which exits reheated from this second heat exchange is introduced into the heating chamber of the boiler, in place of that exiting previously from the first heat exchange;

- on exiting from these n hollow reheating plates, the small cooled-down flow of heat-transfer gas is mixed with the flow of heat-transfer gas exiting from the N hollow distillation plates, then the mixture is subjected to said first heat exchange, in order to exit from it at said temperature T_4;

- the liquid to be distilled exiting from the first heat exchange is reheated, during said third heat exchange, by the distilled liquid which has condensed on the internal faces of the walls of the (N+n) plates;

- the flow rates of distilled liquids, produced at the outlet from these (N+n) hollow plates and during the first heat exchange, are mixed then removed and recovered.

10. Distillation method according to claim 8 or 9, characterized in that:

- the heat source is a boiler provided with a heating chamber operating at a constant level of liquid and suited to producing very hot liquid and vapour jets;

- the very hot liquid to be distilled is spread over a support, in order to be swept by the flow of heat-transfer gas at temperature T_2;

- the vapour jets constitute means of propulsion intended to cause the flow of heat-transfer gas to circulate in closed circuit and in the opposite direction to natural convection, and, moreover, to reheat and supersaturate this flow in order to take it to an optimum or simply effective temperature T_1;

- the heating power of the boiler is variable and the flow rates of hot liquid and of vapour are controlled by adjusting this power.

11. Distillation method with vapour diffusion and heat-transfer gas, according to one of claims 6 or 7, characterized in that, according to a second set of arrangements,

- the flow of saturated gas at temperature T_1 is introduced at the bottom of the hollow distillation plates and it exits at the top at temperature T_3;

- at the outlet from the hollow distillation plates, this flow of gas is subjected to a cooling-down heat exchange, ensured by a cold source at temperature T_{L1}, constituted by the entering flow of liquid to be distilled, so that, given the mass and thermal characteristics of this flow of gas and of this flow of liquid, the temperature T_3 of the flow of gas is reduced to an optimum temperature T_4 and the temperature of the liquid taken to T_{L2};

- after this heat exchange, the liquid to be distilled at temperature T_{L1} or T_{L2} is poured over the top of the external faces of the walls of the hollow plates, it runs down along these external faces and leaves them at a temperature of approximately T_2;

- the flow of gas, at temperature T_4, is introduced at the top of the inter-plate spaces and it exits at the bottom at temperature T_2;

- at the outlet from the inter-plate spaces, the flow of gas at temperature T_2 is subjected to the action of a heat source, in order to be reheated and saturated with vapour, and taken to an optimum or simply effective temperature T_1;

- the flow of gas at temperature T_1 is introduced at the bottom of the hollow plates and, at least by natural convection, it rises inside these plates, then it exits at

the top, it then passes through a zone where it undergoes said cooling-down heat exchange then, at temperature T_4, it enters and runs down by gravity in the inter-plate spaces;

- the distilled liquid, condensed during the cooling-down heat exchange and that condensed along the internal faces of the walls of the hollow plates are collected, then removed;

- the concentrated liquid is collected at the bottom of the inter-plate spaces with a view to immediate or subsequent removal.

12. Distillation method according to claim 11, characterized in that,

- on exiting from the inter-plate spaces, the concentrated liquid is reheated by a heat source;

- the flow of gas exiting from these inter-plate spaces is reheated and saturated by appropriate physical contact with the concentrated liquid, reheated by this heat source;

- the slightly more concentrated liquid which results from the preceding operation is, if appropriate, collected in a reservoir, from where it is removed periodically.

13. Distillation method according to claim 11, characterized in that:

- before being removed in continuous manner, the distilled liquid collected circulates from the bottom to the top in a small group of hollow auxiliary heat recovery plates, separated by narrow inter-plate spaces;

- if appropriate, the same applies to the condensed liquid collected;

- these hollow auxiliary heat recovery plates are at the same time rigid, thin and provided with external, hydrophilic or wettable coatings;

- liquid to be distilled, preferably as cold as possible, is poured over the top of these coatings;

- a part of the flow of gas at temperature T_4 circulates from the top downwards along these thus-moistened coatings;

- the flow of saturated hot gas which leaves these coatings is added to that which exits from the inter-plate spaces of the hollow distillation plates, then the mixture is reheated and saturated in order to reach an effective or optimum temperature T_1;

- the distilled and concentrated liquids exit cooled down again at the top of these hollow auxiliary heat recovery plates then they are removed and at least one of them is recovered.

14. Distillation method according to claim 12 or 13, characterized in that:

- the heat source concerned is a solar boiler, suited to heating a thin hydrophilic mat, inclined as a function of the latitude of the installation site;

- the concentrated hot liquid which flows from the inter-plate spaces, ends up in a trough into which the top part of this hydrophilic mat is dipped;

- the concentrated hot liquid which flows from this hydrophilic mat is collected in a heat-insulated reservoir, the surface of which is both uncovered and also as wide as possible and the depth sufficient for it to be able to contain the concentrated liquid produced during one day;

- the flow of gas, which exits from the inter-plate spaces, is directed towards the surface of the hot liquid contained in this reservoir, in order to sweep across it and thus benefit from preheating;

- then, the flow of gas thus preheated sweeps over this hydrophilic mat, heated during the day and constantly moistened by the concentrated liquid, in order to be reheated and saturated, before entering the bottom of the hollow distillation plates;

- the reservoir is emptied every morning, so that a limited additional distillation can be carried out during the night.

15. Distillation method according to claim 12 or 13, characterized in that the heat source concerned is a heating tube provided with a hydrophilic coating with clear slopes, over which is poured the concentrated liquid which flows from the inter-plate spaces, the very concentrated liquid produced being removed continuously.

16. Distillation method according to claim 11, characterized in that:

- the heat source concerned is constituted by vapour jets, installed at a good distance and orientation, upstream of the inlets to the hollow plates;

- these vapour jets reheat and saturate the flow of gas exiting from the inter-plate spaces and, moreover, they constitute auxiliary means of propulsion which increase the speed of circulation by natural convection of this flow and can thus give an optimum value to the transit time of this flow of gas in the hollow plates;

- the concentrated liquid exiting from the inter-plate spaces is collected and removed continuously.

17. Distillation method according to claims 11 or 16, characterized in that a ventilator is used just upstream of the inter-plate spaces, in order to increase the circulating flow.

18. Still, in particular for producing fresh water or concentrates, according to the distillation method of claim 4, comprising:

- a distillation unit with vapour diffusion and heat-transfer liquid, constituted by a large number of thin hollow plates, alternately hot (10) or cold (12), with hydrophilic or wettable coating, installed vertical or inclined, in a heat-insulated treatment chamber, with narrow inter-plate spaces (14), filled with a non-condensable gas, in particular air at atmospheric pressure;

- means for causing the liquid to be distilled to circulate, in closed circuit and in heat-transfer fluid, from the top downwards inside the hot plates then from the bottom upwards, inside the cold plates;

- a heat source (17,18,19), arranged between the top ends of the cold and hot plates;

- a cold source (20, 22), arranged between the bottom ends of the hot and cold plates;

- means (11a,b and 13a,b) for connecting the top and bottom ends of the plates (10,12) respectively to the inlet to and outlet from the heat and cold sources;

- means (11c) for pouring hot liquid to be distilled over the top of the external faces of the hot plates;

- means (32) for collecting the distilled liquid which runs down along the external faces of the walls of the cold plates and similar means (30) for collecting the concentrated liquid which runs down along the external faces of the walls of the hot plates (10);

characterized in that it comprises:

- a heat source (17), suitable for taking the temperature of the liquid to be distilled to a value as close as possible to its boiling temperature at atmospheric pressure;

- a heat exchanger (22) comprising a casing (28) enclosing two active elements (24,26), these elements preferably being of the monobloc type with multiple hollow folds (250);

- a reservoir (36) containing the liquid to be distilled, arranged above the plates and connected to the inlet to the casing (28);

and in that:

- the means (30-32) for collecting distilled and concentrated liquids are connected to the inlets to the active elements (24,26) and the outlets from these elements end respectively in removal troughs (38,40);

- the outlet from the casing (28) is connected to one inlet to a mixer (20), the other inlet to which is connected, by the coupling device (11b), to the outlet from the hot plates (10), and the outlet from this mixer (20), is connected by the coupling

device (13b) to the inlet to the cold plates (12), the temperature of the heat-transfer liquid then being T_4;

- the means for causing the heat-transfer liquid to circulate in the hollow plates (10-12), are suitable for determining a transit time t of this liquid in these plates, which gives to the composite variable t.dT a value corresponding to the optimum temperature T_3.

19. Still with vapour diffusion and heat-transfer liquid according to claim 18, characterized in that the means for causing the liquid to be distilled to circulate in the hollow plates are constituted either by a pump or by the natural convection engendered by an appropriate difference in levels between, on the one hand, the top ends of the hot (10) and cold (12) plates and, on the other hand, the inlet and outlet orifices of the heating chamber (19) of a boiler (18), installed below.

20. Still, in particular for producing fresh water or concentrates, according to the distillation method of claim 5, comprising:

- a distillation unit with vapour diffusion and heat-transfer liquid, constituted by a large number of thin hollow plates, alternately hot (10') or cold (12'), with a hydrophilic or wettable coating (16'), installed, vertical or inclined, in a heat-insulated treatment chamber, with narrow inter-plate spaces (14'), filled with a non-condensable gas, in particular air at atmospheric pressure;

- a trough (32') for collecting the distilled liquid which runs down along the external faces of the walls of the cold plates (12') and another (30'), for collecting the concentrated liquid which runs down along the external faces of the walls of the hot plates (10'),

characterized in that:

-the inlet duct (11'a) of the hot plates (10') and the outlet duct (13'a) of the cold plates (12') are situated at the bottom of these plates;

- the outlet duct (11'b) of the hot plates (10') and the inlet duct (13'b) of the cold plates (12') are situated at the top of these plates;

- the heating chamber (19') of a boiler (18'), arranged between the outlet duct (13'a) of the cold plates (12') and the inlet duct (11'a) of the hot plates (10'), engenders in these plates a circulation in closed circuit, by natural convection;

- spouts (11'c), connected to the outlet duct (11'b) of the hot plates (10'), are installed above the coatings (16') of these plates;

- a reservoir (36'), containing the liquid to be distilled, is arranged above the plates (10',12');

- a mixer (20'), arranged under the reservoir (32') and above the plates (10',12'), comprises an inlet connected to the outlet from this reservoir (36'), another connected to the outlet duct (11'b) of the hot plates (10'), and an outlet connected to the inlet duct (13'b) of the cold plates (12') ;

- the heat source (17') of the boiler (18') is suitable for taking the temperature of the liquid to be distilled to a value as close as possible to its boiling temperature at atmospheric pressure;

- a valve (34'), installed between the reservoir (36') and the mixer (20'), is suitable for controlling the entering flow of the liquid to be distilled and the difference in temperature (T_3-T_4).

21. Still with vapour diffusion and heat-transfer gas, in particular for producing fresh water or concentrates, according to the distillation method of claim 8 comprising:

- a distillation unit, constituted by a large number N of thin hollow plates, large and separate (54) or small and integral (256-250), and by narrow inter-plate spaces (58 or 260), filled with a non-condensable gas, in particular air at atmospheric pressure, constituting said heat-transfer gas;

- means of propulsion for causing the saturated heat-transfer gas to circulate, in closed circuit, from the top downwards inside the hollow plates and from the bottom upwards in their inter-plate spaces;

- means for pouring the hot liquid to be distilled over the top of the plates (54 or 256);

- means for collecting the distilled liquid, condensed on the internal faces of the plates, and means for collecting the condensed liquid which flows along their external faces;

- a heat source, arranged between the top ends of the plates and of the inter-plate spaces, and a cold source, arranged between their bottom ends;

characterized in that:

- the heat source is installed just above the plates (54 or 256-293), in the middle of the flow of heat-transfer gas exiting from the inter-plate spaces in order to enter inside the hollow plates (54 or 256-293), in order to take the temperatures of this flow to T_2 and T_1 and, on this occasion, to supersaturate it in vapour;

- this heat source comprises a tray, if appropriate covered with a spongy mat (100 or 361), provided with a base perforated with small holes, associated with ducts and/or distribution wicks (102 or 362), this tray being installed under one or more tubes for extraction (124 or 348) of the hot liquid to be distilled present in the heating chamber (118 or 336) of a boiler (120 or 338);

- the cold source is constituted by a first heat exchanger (80 or 318) comprising an active element (84 or 318), enclosed in a casing (82 or 320);

- the inlet of this active element (84 or 318) is connected to a reservoir (76 or 314) of cold liquid to be distilled, if appropriate, through an auxiliary device with natural cooling, and its outlet, connected by appropriate means (86 and/or 66 or 326) to the inlet to the heating chamber (118 or 336) of the boiler (120 or 332);

- the inlet of the casing (82 or 320) is connected to the outlet from the N separate (54) or integral (256-293) hollow plates, and its outlet to the inlet to the inter-plate spaces (58 or 260);

- the means of propulsion are constituted by a ventilator (92), installed upstream of the inlets to the inter-plate spaces (58), and/or by vapour jets (347), engendered upstream of the inlets to the hollow plates (293);

- the casing (82 or 320) comprises a duct (83 or 376) for removal of the distilled water produced, which cooperates with the means (108,115 or 378) intended for collecting that which flows from the bottom of the (N) hollow plates.

22. Still with vapour diffusion and heat-transfer gas , according to claim 21, characterized in that:

- a small number n of hollow auxiliary plates (63 or 294) is installed in the vicinity of the N hollow plates of the distillation unit, in order to constitute a second heat exchanger with counter-current operation, between a small part of heat-transfer gas, saturated at temperature T1 and the flow of liquid to be distilled which exits from a third heat exchanger (88 or 294), arranged between the outlet from the first heat exchanger (80 or 318) and the means for collecting (108, 112 or 320) distilled liquids which flow over the internal faces of the walls of the (N+n) hollow plates (54 and 63 or 293 and 295);

- the N hollow plates of the distillation unit (54 or 293) and the n auxiliary plates (63 or 294) open into a duct with a common outlet, connected to the casing (82 or 320) of the first heat exchanger (80 or 318, 320);

- the distilled liquid which exits from the n auxiliary plates (63 or 294) is added to those which exit from the N distillation plates (54 or 293) and from the casing (82 or 320) of the heat exchanger (80 or 318, 320).

23. Still with vapour diffusion and heat-transfer liquid, according to one of claims 18, 20, characterized in that the means for connecting the common top (148) and bottom channels (163) of the separate multiple ducts (142) of large hollow rectangular plates (10, 12 or 54, 63), odd or even-numbered, to the inlets and outlets

of the heat (17,18,19 or 118,120,122) and cold sources (20,22 or 80), are constituted by:

- two coupling washers (172,174), inserted into two opposite corners of the hollow plates, each washer being provided (1) with several holes (192) made through in its thickness, directed towards the top (148) or bottom (163) common channels of the separate ducts (142) of the hollow plates, (2) with a circular flange (188) the two faces of which are welded to the internal faces of the hollow plates and (3) shoulders upstream and downstream for assembly (171,173);

- each washer (172,174) having a thickness equal to twice the pitch installation of the hollow plates (10,12 or 54,66), a cutout (188) is made in the free top corner of these plates;

- the washers are stacked and firmly clamped, so as to constitute a leak-free line, by a tie rod (186), comprising a base (194) resting on the washer downstream of the stack, a rod (196) of appropriate length and a T-shaped coupling (180), the element of which, coaxial with the stack of the washers, has its two ends equipped with supports, one as a ring (202) in contact with the washer upstream of the stack and the other in the form of a cup (200), with a central hole passed through by the end of the tie rod (186), provided with an O-ring seal (204), the end part of this tie rod being threaded and provided with a clamping nut (208).

24. Still with vapour diffusion and heat-transfer liquid, according to claim 18 or 20, characterized in that the means for pouring the hot liquid to be distilled over the top of the coatings (16) of the hot plates (10), include one or more spouts (228) opening above a spongy fabric (226), arranged above the hot (10) and cold (12) plates, the top parts of these plates (10-12) being separated from each other by cellular inserts (214) and the cold plates (12) as well as the two inserts (214) which are contiguous with them, being protected from any contact with this hot liquid by impermeable covers (216), preferably provided with hydrophilic coatings (217), in contact with that (16) of the hot plates (10).

25. Still with vapour diffusion and heat-transfer gas, according to claim 21 or 22, characterized in that the means for pouring the hot liquid to be distilled over the top of the coatings (60,60') of the plates (54,54'), are constituted by one or more ducts (102,102') associated with spouts (228) opening above bands of spongy fabric (226), arranged, at a certain distance from each other, above the plates (54,54'), the top parts of these plates being separated from each other by cellular inserts (214), sections of these inserts emerging in the spaces which separate the bands of spongy fabric.

26. Still according to claim 21 comprising a monobloc distillation heat exchange element, comprising:

- one or more elementary heat exchangers (250), each constituted by a single active part (254), without either assembly or welding, formed by a stack of pairs of elongated plates, hollow and thin, connecting and globally symmetrical (256a,b), produced, at an appropriate temperature, by controlled compression of a thin-walled blank (276), having the form of accordion bellows produced by blow-moulding;

- the internal faces of the walls of a hollow plate and the external faces of the walls of two contiguous plates, are at all points separated from each other by narrow, more or less constant spaces (260);

- these pairs of hollow plates (254) constitute the elementary ducts of the active part which comprises elongated central parts (252) the two ends of which are connected to each other, by two hollow couplings (262,264);

- each elementary duct of the active part possesses two main feed lines the axes of which are identical with the stacking axes of the end couplings;

- one of the ends of each line ends in a connecting tube (266,268) of the active part;

- one or more active exchange elements (254), made of polymer or glass, are installed fixed in a casing (251), provided with two connecting tubes (274,276) and formed by two half-shells (251,253), fixed in tight manner, one to the other, so as to completely surround, with a small gap, this active element or elements (254);

- characterized in that:

- when the active element (254) is made of polymer, a hydrophilic coating (282) is fixed on the external wall of each pair of plates (256 a,b);

- when the active element (254) is made of glass, the external faces and, if appropriate, the internal faces, of its plates are given a dull finish by an appropriate chemical treatment, in order to become wettable;

- a hydrophilic layer (286) is installed on the tops of the different pairs of plates of each active element (254), just above the connecting tube (274) of the casing of this element.

27. Still, in particular for producing fresh water or concentrates, according to the distillation method of claim 11, characterized in that:

- it comprises one or more distillation units, with vapour diffusion and heat-transfer gas, installed between a bottom stage and a top stage;

- each distillation unit is constituted by a large number of plane, thin and flexible, hollow plates with tightened walls (400_{1-6}), each being, on the one hand,

provided with an inlet (452_{1-6}) and an outlet (454_{1-6}) with the same elongated vertical shape, diagonally opposite and provided by means of short

spacers (448_{1-5} and 450_{1-5}), at the bottom of a lateral edge of each plate (400_{1-6}) and at the top of the other, and on the other hand, separated from its contiguous hollow plates by interplate spaces (457_{1-5}), bordered laterally by long spacers (456_{1-7}) having the same thickness as it;

- the inlets (452_{1-6}) to the hollow plates (400_{1-6}) of the distillation unit are arranged at the top of a bottom vent (426), provided in said bottom stage ;

- in this bottom vent (426) a heat source is installed (422), suitable for reheating and supersaturating the heat-transfer gas which exits from the inter-plate spaces (403_{1-5}) and then passes through a wide collecting space (432) of this bottom stage;

- the outlets (454_{1-6}) from the hollow plates (400_{1-6}) open into a top vent (436), provided in said top stage ;

- at the top of this top chimney (436) are installed monobloc active heat-exchange elements (438), fed by the cold liquid to be distilled, which connect this top vent (436) and a wide collecting space (443) of this top stage ;

- the inlets (457_{1-5}) to the inter-plate spaces appear at the bottom of this top unoccupied space (443) ;

- one or more tubes (442) linking the outlets from the monobloc heat-exchange elements (438) to one or more distributors (444) of liquid to be distilled, arranged transversely above each distillation unit and suitable for pouring liquid over the top of each hollow distillation plate ;

- means for causing the heat-transfer gas to circulate in closed circuit in the hollow plates (400_{1-6}), in the inter-plate spaces (457_{1-5}) and in the associated bottom (426) and top (436) vents, comprise natural convection ;

- flat ducts (414) suitable for collecting the concentrated liquid are provided at the bottom of the inter-plate spaces (457_{2-6});

- means (412-416) for collecting the distilled liquid, condensed in the plates (400_{1-6}) and on the walls of the heat-exchange elements (438) are arranged under these plates (400_{1-6}) and under these elements and they have a shared opening.

28. Still according to claim 27, characterized in that :

- a heat recovery unit is associated with each distillation unit ;

- each heat recovery unit comprises one or, if appropriate, two groups of thin and rigid auxiliary hollow plates (variant of 140_{1-3}), with hydrophilic or wettable external coatings, assembled with narrow inter-plate spaces, with inlets and outlets arranged exactly like those of the interplate spaces (457) of the distillation unit ;

- means (444) for pouring liquid to be distilled as cold as possible are installed above these coatings;

- each of these hollow auxiliary plates possesses an inlet situated at the bottom and an outlet situated at the top;

- the suction tube of a siphon dips into the collecting means (416) of the distilled liquid and it is connected to the inlet to a group of hollow auxiliary heat recovery plates;

- if appropriate, the suction tube of another siphon dips into the collecting means (434) of the reheated concentrated liquid and they are connected to the inlet of another group of auxiliary hollow heat recovery plates;

- the drainage tube or tubes of this siphon or these siphons is or are linked to the outlet(s) of this groups or these groups of hollow auxiliary plates and it (they) open(s) at levels situated below those of the inlets to the suction tubes of the two liquids concerned.

29. Still with vapour diffusion and heat-transfer gas, according to one of claims 21 or 27 with a main component of a plane, thin and flexible hollow plate, ($400_{1\text{-}6}$), suitable for constituting one of the elements of the distillation unit of the still, characterized in that:

- the component comprises an elongated rectangular fleece ($402_{1\text{-}6}$) made of polymer;

- the fleece ($402_{1\text{-}6}$) is folded in two, with end edges welded to a tension bar ($406_{1\text{-}6}$) made of polymer, so as to clear two narrow projecting slopes (414) for the fleece (402) and two projecting ends (408 a-b) of equal lengths, for the bar (406);

- a suspension rod ($404_{1\text{-}6}$) made of polymer is welded to the fleece ($402_{1\text{-}6}$), on both sides of the fold, so as to clear two projecting ends of equal lengths;

- a first short spacer made of polymer ($448_{1\text{-}6}$), is fixed squarely to one end of the suspension rod ($404_{1\text{-}6}$) and arranged free between edges of the slopes of the folded-back fleece;

- a second short spacer made of polymer ($450_{1\text{-}6}$), is fixed squarely to the opposite end of the tension bar ($406_{1\text{-}6}$) and arranged free between the other edges of the slopes of the folded-back fleece;

-the polymer or polymers used have a good mechanical resistance to at least 90° C;

- the thickness of the fleece is approximately comprised between 100 and 250 microns;

- the thicknesses of the tension bar, suspension rod and two spacers are identical and approximately comprised between 2 and 5 millimetres and their widths approximately comprised between 2 and 5 centimetres;

- the surface area of one face of the fleece (402_{1-6}) thus folded is approximately comprised between 20 and 100 square decimetres, its width likewise comprised between 4 and 8 decimetres and the lengths of the bar (406_{1-6}) and of the rod (404_{1-6}), approximately 10 centimetres greater than the width of the fleece;

- the folded fleece (402_{1-6}) comprises an external, hydrophilic or wettable coating, having a thickness of 80 to 150 microns;

- the tension bar (406_{1-6}) comprises, approximately 10 centimetres from one of its ends, a longitudinal cut (412) and/or a flat wick, in order to constitute a means of extraction of the distilled liquid;

- the projecting slopes of the fleece (402_{1-6}) are raised, folded slantwise and compressed, in order to constitute a flat duct (414) for removal of the concentrated liquid, preferably inclined towards the other end of the pressure bar.

30. Still according to claim 21 or 27 or 29 with a distillation unit, characterized in that:

- the unit comprises a large number of components, the ends of which projecting over the suspension rods (404_{1-6}) rest on two parallel horizontal girders, mounted fixed on a framework;

- two other girders, parallel to the preceding ones, mounted on springs fixed to said framework, are installed resting on the projecting ends of the tension bars (406_{1-6}) of said components, so as to give an appropriate pressure to the slopes of the fleeces (402_{1-6}) constituting these components;

- two long spacers (456_{1-6}) made of polymer are installed on both sides of each of said components, so as to constitute the lateral edges of the inter-plate spaces (457_{2-6}) and two end spaces (457_{1-7});

- rigid panels, linked by tie rods, are installed on both sides of the distillation unit thus assembled in order to clamp and pinch its different constituents, in order to ensure a sufficient lateral tightness for the hollow plates (400_{1-6}), the inter-plate spaces (457_{2-6}) and two free end spaces (457_{1-7}) of this distillation unit.

31. Still according to claim 21 with a boiler characterized in that:

- the boiler is constituted by a tubular radiator (338), installed in an elongated heating chamber (336), intended to be passed through by an appropriate heating fluid, suitable for taking to boiling under slight overpressure the liquid to be distilled, which circulates in this chamber, with counter-current of the heating fluid;

- an inlet part (334), is provided upstream of this heating chamber (336), and it comprises a truncated-cone-shaped opening (354) associated with a closing device (356) of the same shape, integral with a float (358), the liquid to be distilled being introduced through this opening (354), in order to keep the level of this liquid in this chamber (336) constant;

- the heating chamber (336) comprises at least one extraction duct (348) of the boiling liquid and at least one calibrated opening from where vapour jets (347) escape;

- the extraction ducts (348) open above a tray, with a base perforated with small holes, if appropriate covered with a thin spongy mat (361);

- this tray is suitable for being swept by the flow of heat-transfer gas exiting from the inter-plate spaces;

- the holes in the tray are connected through the individual ducts (362) with the hydrophilic coatings of the active evaporation elements (292);

- the vapour jets are suitable for mixing with the flow of gas leaving the tray, in order to constitute means of propulsion of this flow of gas as well as means for reheating and supersaturating it.

32. Still according to claim 27 with a heat source characterized in that the heat source is a solar boiler (120'), suitable for evaporating the liquid that it treats, and, for this purpose, it is constituted by a flat solar collection unit (118', 119'), the base (122') of which is a black impermeable fleece, provided behind a thin hydrophilic mat, installed on a tightened grid, and comprising, at its upper end, a projecting slope, intended to be dipped into a feed trough (105') containing the concentrated liquid which exits from the inter-plate spaces (58').

33. Still according to claim 27 with a heat source, characterized in that the source is constituted by a heating tube (422), passed through by an appropriate heating fluid and covered with a thin hydrophilic mat (424) with clear slopes, above which are arranged spouts (420 a,b) for the concentrated liquid which flows from the inter-plate spaces.

34. Still according to claim 27 with a heat source, characterized in that the source is constituted by vapour jets produced by a heating tube (422) closed at one end, provided with calibrated orifices made at regular intervals along a generating line and fed by a vapour generator with slight overpressure and appropriate flow rate.

35. Still according to claim 34 with a vapour generator for the heat source, characterized in that:

- the generator is constituted by a pot provided with a lid, suitable for being fixed tightly and resisting an overpressure of at least 40 hPa;
- this lid is equipped with a water intake and a vapour intake;
- its water intake is extended by a duct ending in a needle-valve closing device (354, 356) associated with a float (358), suitable for establishing a constant level of water in this pot ;
- the water intake is intended to be connected by a tube to an appropriate device (113') associated with the still, suitable for providing distilled water under slight overpressure;
- the vapour intake is intended to be connected by a heat-insulated tube to the free end of the heating tube (422) with vapour jets, constituting said heat source.

36. Still with vapour diffusion and heat-transfer gas according to claim 27, characterized in that it comprises a ventilator helix (92), installed in the top collecting space (443) just upstream of the inlets to the inter-plate spaces (457_{1-6}) and/or a heating tube with vapour jets (422), installed in the bottom vent (426) upstream of the inlets to the hollow distillation plates, in order to constitute a means of propulsion and a heat source, alone or in cooperation with this helix and/or with another heat source of a different type.

37. Still according to claim 21, 27 or 28 with a natural refrigerator for reducing as well as possible the temperature of the liquid to be distilled entering the still, characterized in that the refrigerator comprises:

- thin hollow auxiliary plates (140) provided, on the one hand, with external walls provided with hydrophilic coatings and, on the other hand, appropriate upstream and downstream means of connection (172-180);
- relatively large inter-plate spaces;
- tubes for linking a reservoir (76) of liquid to be distilled to means (226, 228) for pouring this liquid over these coatings;
- tubes for respectively linking said upstream and downstream means of connection with the reservoir (76) and with the inlet duct (77' or 440) of the cooling heat exchanger (84' or 438), associated with the distillation unit of the still or that of the distributor of liquid to be distilled (444) of its heat recovery unit.